CLAIMS

We claim:

1. A set of one or more orthodontic brackets for a patient, said brackets having a bracket bonding pad for bonding the bracket to the tooth of the patient and a slot for receiving an archwire having either a side portion having a flat surface or alternatively an oval cross-section and a major axis, the improvement comprising:

said slots of each of said brackets oriented in approximate parallel alignment relative to its respective bracket bonding pad,

whereby when said set of brackets are installed on the teeth of said patient and said archwire is inserted in said slots, said archwire is canted relative to an occlusal plane such that said side portion or alternatively said major axis is disposed in approximate parallel alignment to the surface of the teeth at the location of where said archwire is inserted into said slots, whereby the overall thickness of said brackets may be decreased.

2. The set of brackets of claim 1, wherein said archwire has a rectangular or square cross-sectional shape and has first and second pairs of opposed parallel sides, and wherein one of said sides in said first pair of sides of said archwire has a height greater than one of said sides in said second pair of sides, and wherein said first pair of sides are oriented parallel to said bracket bonding pad when said archwire is inserted into said slots.

3. The set of brackets of claim 1, wherein each bracket bonding pad in said set of brackets has a three-dimensional tooth-facing surface shaped to conform to the three-dimensional surface of its respective tooth.

4. The set of brackets of claim 3, wherein said set of brackets comprise lingual brackets and wherein the bracket bonding pad for each of said brackets covers at least 50 percent of the lingual surface of the respective tooth.

5. The set of brackets of claim 3, wherein said bracket bonding pad has a second opposite surface having a three-dimensional shape corresponding to said three-dimensional tooth-facing surface.

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6. The set of brackets of claim 1, wherein said set of brackets comprise a set of lingual brackets.

7. The set of brackets of claim 1, wherein said set of brackets comprise all the brackets for treatment of an arch of the patient.

8. The set of brackets of claim 1, wherein said set of brackets comprise less than all the brackets for treatment of an arch of the patient.

9. The set of brackets of claim 1, wherein said set of brackets include a set of brackets for placement on the lingual surface of the front teeth of the patient.

10. The set of brackets of claim 1, wherein said set of brackets comprises a first subset of brackets for placement on the lower arch and a second subset of brackets for placement on the upper arch.

11. The set of brackets of claim 1, wherein said bracket(s) are manufactured using a rapid prototyping process from a three-dimensional virtual model of said bracket(s).

12. The set of brackets of claim 11, wherein said rapid prototyping process uses a material suitable to be used directly as a bracket.

13. The set of brackets of claim 11, wherein said rapid prototyping process forms a model of at least one bracket, and wherein said model is used in a casting process to manufacture said bracket.

14. The set of brackets of claim 5, wherein the thickness of said bracket bonding pad varies such that the periphery of said bracket bonding pad is thinner than the center of said bracket bonding pad.

15. The set of brackets of claim 5, wherein said bracket bonding pad has a thickness of 0.3 mm or less.

16. A bracket for a patient, said bracket comprising a bonding pad for bonding to the tooth of the patient and a slot for receiving an archwire,

wherein said bracket bonding pad comprises a three-dimensional tooth-facing surface conforming to the shape of the tooth and an opposing surface also conforming to the shape of the tooth and wherein said slot of said bracket is oriented in approximate parallel alignment relative to its respective bracket bonding pad.

17. The bracket of claim 16, wherein said bracket comprises a lingual bracket.

18. A set of brackets in accordance with the bracket of claim 16 for treatment of a plurality of teeth of an arch of a patient.

19. The bracket of claim 16, wherein said bracket comprises a labial bracket.

20. The bracket of claim 16, wherein said tooth-facing surface covers at least 50 percent of the lingual or labial surface of the tooth to which it is to be bonded.

21. The bracket of claim 16, wherein said bracket bonding pad covers a cusp of said tooth.

22. A canted, manufactured archwire, comprising an elongated strip of material having a either a flat surface or an oval cross-section and defining a major axis, wherein said wire is bent during manufacturing to have a shape, in a relaxed condition, such that said archwire is canted relative to an occlusal plane over a substantial arcuate extent corresponding to portions for straightening two or more teeth whereby said flat surface or alternatively said major axis is oriented substantially parallel to tooth surfaces in the vicinity of where said archwire is to be received by archwire receiving receptacles located on said two or more teeth.

23. The canted archwire of claim 22, wherein said archwire is for a set of lingual brackets.

24. A set of two archwires for treating the upper and lower arches of a patient, wherein each of said archwires is canted as claimed in claim 22.

25. The canted archwire of claim 22, wherein said archwire comprises straight slot portions

and intermediate portions between said straight slot portions, said intermediate positions comprising bends and/or twists in said archwire.

26. The canted archwire of claim 22, wherein said canted archwire is formed from a series of incremental bends in the wire made by a computer-controlled wire bending robot.

27. The canted archwire of claim 22, wherein said archwire comprises a wire of rectangular or square cross-sectional shape.

28. A method of manufacturing a canted archwire, comprising the steps of:

defining the location of a set of bracket slots for a set of brackets in three-dimensional space with the aid of a computer, wherein said bracket slots are oriented substantially parallel to the surface of the teeth in the location of where said brackets are to be bonded to said teeth;

supplying a wire bending robot with information corresponding to said location of said set of bracket slots and/or said brackets; and

bending an archwire with said wire bending robot so as to have a shape corresponding to said location of said bracket slots, wherein said archwire has a canted configuration relative to an occlusal plane such that said archwire is oriented substantially parallel to said tooth surfaces.

29. In an orthodontic bracket having a bonding bad for bonding the bracket to a tooth of a patient, the improvement comprising:

said bracket bonding pad having a tooth-facing surface of three-dimensional area extent conforming substantially exactly to the three-dimensional shape of said tooth where said pad is bonded to said tooth, and wherein said bracket bonding pad further comprises an opposite surface having a three-dimensional surface substantially matching the tooth-facing surface, whereby the thickness of said bracket bonding pad may be reduced.

30. The bracket of claim 29, wherein said three-dimensional area extent is sufficiently large that said bracket can be readily, uniquely, and correctly placed and located on said tooth due to the substantial area extent corresponding to the three-dimensional surface of said tooth, and correctly bonded in place on said tooth without the assistance of a bracket placement jig.

31. The orthodontic bracket of claim 29, or claim 30, wherein said three-dimensional area

extent comprises greater than about 50 percent of the lingual or labial surface of said tooth to which said bracket is bonded.

32. The orthodontic bracket of claim 29, or claim 30, wherein said bracket is for bonding to a lingual surface of said tooth.

33. The orthodontic bracket of claim 29, further comprising a slot oriented substantially parallel to said tooth-facing surface.

34. A set of orthodontic brackets for placement on teeth of one of the arches of the patient, wherein each of said brackets are in accordance with the orthodontic bracket of claim 29.

35. An orthodontic bracket as claimed in claim 29, wherein said tooth has a cusp and wherein a portion of said bracket bonding pad covers a portion of said cusp.

36. A method of designing a customized orthodontic bracket for a patient with the aid of a computer, said bracket having a bracket bonding pad, wherein the computer stores or has access to a three-dimensional model of portions of teeth of the patient to which said bracket will be bonded and either stores, or has access to, a library of virtual bracket bodies, comprising the steps of:

determining an area of a tooth at which said bracket bonding pad is to be attached to said tooth;

determining a three-dimensional shape of a tooth-facing surface of said bracket bonding pad, wherein said three-dimensional shape conforms to the three-dimensional shape of said tooth;

determining the three-dimensional shape of a second, opposite surface of said bracket bonding pad;

obtaining a bracket body from said library; and

uniting said bracket body with said bracket bonding pad to form one virtual three-dimensional object representing a bracket.

37. The method of claim 36, wherein said second, opposite surface has a three-dimensional shape corresponding to said tooth-facing surface of said bracket bonding pad.

38. The method of claim 37, wherein said second, opposite surface is determined by creating a normal vector for a plurality of surface elements forming said tooth-facing surface and creating said second surface by shifting said surface elements in the direction of the normal vector by an offset amount equal to the thickness of said bonding pad.

39. The method of claim 36, further comprising the step of modifying the virtual model of the bracket body and/or modifying the bracket bonding pad.

40. The method of claim 39, wherein said modification comprises adding an auxiliary feature to said bracket body.

41. The method of claim 40, wherein said auxiliary feature comprises hooks.

42. The method of claim 40, wherein said auxiliary feature comprises a bite plane.

43. The method of claim 36, wherein said step of combining further comprises the step of viewing, with the aid of said computer, a plurality of virtual teeth and virtual bracket bonding pads attached to said teeth, and shifting the location of said bracket body relative to its respective bracket bonding pad and/or removing parts of the bracket body that interfere with adjacent brackets and/or teeth.

44. The method of claim 36, further comprising the step of removing a portion of the virtual bracket body, said portion comprising a portion that would project into said tooth when said bracket body is combined with said bracket bonding pad.

45. A method of manufacturing a customized orthodontic bracket having a bracket body having a slot and a bracket bonding pad, comprising the steps of:

determining the three-dimensional shape of a customized orthodontic bracket; and

manufacturing said bracket from materials having at least two different hardnesses, a first relatively hard material or materials forming said bracket body and a second relatively soft material or materials forming said bracket bonding pad.

46. The method of claim 45, wherein said step of manufacturing comprises:

forming a model of said bracket using a rapid prototyping process; and

casting said bracket from at least two materials comprising relatively hard material(s) for said bracket body and relatively soft material(s) forming said bracket bonding pad.

47. The method of claim 46, wherein said step of casting comprises a centrifugal casting process.

48. The method of claim 45, wherein said step of manufacturing comprises a laser sintering process.

49. The method of claim 45, wherein said bracket body comprises a feature forming a slot for receiving an archwire, and wherein said slot is oriented parallel to said bracket bonding pad in the location of where said feature is combined with said bracket bonding pad.

50. The method of claim 45, wherein said bracket bonding pad comprises a tooth-facing surface and a second opposite surface, and wherein said tooth-facing surface and second opposite surface have a three-dimensional area extent corresponding substantially exactly to a corresponding three-dimensional area of said tooth.

51. A method of designing and manufacturing a customized orthodontic bracket, comprising the steps of:

a) storing a digital representation of portions of the patient's dentition in a computer;

b) accessing a library of virtual three-dimensional bracket bodies in said computer;

c) determining the shape and configuration of a bracket bonding pad, said bracket bonding pad having a tooth-facing surface conforming substantially exactly to corresponding three-dimensional surfaces of a tooth;

d) combining a bracket body from said library of bracket bodies with said bracket bonding pad to thereby create an individual, customized orthodontic bracket;

e) exporting digital data representing said customized orthodontic bracket from said computer to a manufacturing system for manufacturing said customized orthodontic bracket; and

f) manufacturing said customized orthodontic bracket.

52. The method of claim 51, wherein said manufacturing system comprises a rapid prototyping system manufacturing a representation of said bracket to be used as a positive pattern, and wherein said manufacturing step comprises casting said bracket.

53. The method of claim 51, wherein said manufacturing step comprises fabricating said bracket using a laser sintering process.

54. The method of claim 51, further comprising modifying the digital representation of the dentition on a computer into a desired finish position and wherein steps c) and d) are performed after said teeth are virtually moved to said desired finish position.

55. The method of claim 51, further comprising the step of making a physical model of the teeth of the patient, manipulating the physical model to place the teeth into a desired occlusion, scanning the physical model of the teeth in the desired occlusion, and wherein said digital representation comprises a three-dimensional representation derived from said scanning.

56. The method of claim 51, wherein said bracket bonding pad has a second opposite surface opposite from said tooth-facing surface, and wherein said tooth-facing surface and second opposite surface have a three-dimensional area extent corresponding substantially exactly to a corresponding three-dimensional surface of said tooth.

57. The method of claim 51, further comprising the step of transporting information as to the three-dimensional location of said bracket and/or the slot of said bracket to a wire bending robot for bending a customized orthodontic archwire for said patient.

58. The method of claim 51, wherein said bracket base comprises a feature forming a slot for receiving an archwire, and wherein said slot is oriented approximately parallel to said bracket bonding pad in the location of where said feature is combined with said bracket bonding pad.

59. The method of claim 51, wherein said bracket further comprises a U-shaped inlay in a slot for said bracket.

60. A set of brackets for a patient manufactured according to the method of claim 51.

61. The method of claim 51 wherein steps c) and d) are performed by a user using computer software providing a user access to a 3-D virtual model of the patient's dentition.

62. A method of designing a customized bracket for an individual patient with a computer, comprising the steps of:

a) selecting a virtual bracket bonding pad for a tooth of said patient from a library of virtual bracket bonding pads;

b) selecting a virtual bracket body for said tooth from a library of virtual bracket bodies; and

c) uniting the virtual bracket bonding pad with the virtual bracket body.

63. The method of claim 62, further comprising the step of uniting the virtual bracket boding pad and virtual bracket body with a virtual auxiliary bracket device to thereby form said bracket.

64. The method of claim 62, further comprising the step of removing a portion of the virtual bracket body that would otherwise project into said tooth.

65. The method of claim 62, further comprising the step of exporting digital data representing the said bracket after performing step c) to a machine operating a rapid prototyping process.

66. The method of claim 62, wherein a user visually observes and controls the performing of step c) by operating 3D graphics software on said computer to thereby arrive at a customized configuration of said bracket bonding pad and said bracket body.

67. The method of claim 62, wherein step a) further comprises determining the shape of said three-dimensional virtual bracket bonding pad such that said pad fits the three-dimensional shape of said tooth

68. The method of claim 67, and wherein said bracket bonding pad has an opposite surface that further conforms to the three-dimensional shape of said tooth.

69. The method of claim 62, wherein said bracket body comprises a feature forming a slot for

receiving an archwire and wherein said slot is oriented substantially parallel to said bracket bonding pad.

70. The method of claim 62, wherein said step of uniting comprises the step of filling a gap in three-dimensional virtual space between said virtual bracket bonding pad and said virtual bracket body.

71. The method of claim 62, wherein the step of uniting results in a bracket configuration in which a portion of said bracket body projects into space that would be occupied by said tooth, and wherein the method further comprises the step of removing said portion.

72. The method of claim 62, wherein said step of uniting results in a bracket configuration in which said virtual bracket body and said virtual bracket bonding pad fit to each other without requiring removing a portion of said virtual bracket body.

73. The canted archwire of claim 22, wherein said archwire comprises a cobalt chromium wire and wherein said cobalt chromium wire is bended with a wire bending robot.

74. The method of claim 28, wherein said archwire comprises a cobalt chromium wire.

75. A method for bending and heat treating an archwire, comprising the steps of

supplying said archwire to a wire bending robot,

bending said archwire with said wire bending robot to have a predetermined configuration for a particular orthodontic patient, and

heat treating said archwire while said wire is held by said wire bending robot.

76. The method of claim 75, wherein said archwire comprises a cobalt chromium wire.

77. The method of claim 75, wherein said archwire is bent in a series of bends and wherein said step of heat treating comprises heating said wire after performing each of said bends in said series of bends.

78. The method of claim 77, wherein said heat treating comprises supplying a current through said wire to thereby provide a resistance heating to said wire.